Cooperative Agreement Modeling Report
S.H. Bell
East Liverpool, Ohio

U.S. Environmental Protection Agency Region 5
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I. Introduction

The U.S. Environmental Protection Agency (USEPA) Region 5 Air and Radiation Division is funding a study through the USEPA Regional Applied Research Efforts (RARE) Program. The study, "An Epidemiologic Health Study of Manganese Exposure in East Liverpool, Ohio" is being conducted by Rosemarie Bowler, PhD, Psychology Department, San Francisco State University (SFSU). Data collection occurred in November 2011.

USEPA Region 5 (R5) agreed to perform ambient dispersion modeling to support this study. The modeling analysis will provide estimates of manganese concentration at locations as specified by SFSU and Agency for Toxic Substances and Disease Registry (ATSDR). These predicted concentrations will be used to calculate a cumulative exposure index.

II. Background

The group being studied in this cooperative agreement is located in East Liverpool, Ohio. R5 agreed to perform ambient dispersion modeling for S.H. Bell, located in East Liverpool in Columbiana County, Ohio. This facility operates as a storage, transfer, and warehousing facility capable of processing, crushing, screening, and packaging of materials. Monitors located near in East Liverpool near S.H. Bell have routinely had the highest manganese concentrations in the United States.

III. **Model Selection**

The AERMOD atmospheric dispersion modeling system is an integrated system that includes three components:

- A steady-state dispersion model designed for short-range (up to 50 kilometers) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data preprocessor (AERMET) that accepts surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux. Vertical profiles of wind, turbulence and temperature are created for use in AERMOD.
- A terrain preprocessor (AERMAP) which provides a physical relationship between terrain features and the behavior of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

AERMOD can handle multiple source types, including point, area, and volume sources in rural or urban environments situated in simple or complex terrain, and the model can calculate both wet and dry deposition. Plumes are treated as continuous, buoyant plumes, using Gaussian dispersion in the horizontal and vertical for stable atmospheres, but treatment is non-Gaussian in the vertical for unstable atmospheres. AERMOD also includes PRIME (Plume Rise Model Enhancements), which is an algorithm for modeling the effects of downwash created by the pollution plume flowing over nearby buildings.

Special features of AERMOD include its ability to treat the vertical inhomogeneity of the planetary boundary layer, special treatment of surface releases, irregularly-shaped area sources, a three plume model for the convective boundary layer, limitation of vertical mixing in the stable boundary layer, and fixing the reflecting surface at the stack base. AERMOD also includes an improved treatment of dispersion in the presence of intermediate and complex terrain.

When applying the AERMET meteorological processor, the user must determine appropriate values for the three required surface characteristics for use in AERMET: surface roughness length, albedo, and Bowen ratio. These parameters were developed using AERSURFACE, a related but optional component that follows the recommendations laid out in the AERMOD Implementation Guide.

IV. Geophysical Data

S.H. Bell is located in an industrialized river valley in East Liverpool, OH. It is situated in moderately complex terrain. Near the source, the river valley is winding and is approximately 0.5 km wide.

Several types of geophysical data are required as input to AERMOD. Land use/land cover data and 1-degree National Elevation Dataset elevation data for the study area was acquired from the United States Geological Survey Seamless Server.

V. Meteorological Data

National Weather Service (NWS) hourly surface observations, National Climatic Data Center (NCDC) 1-minute surface data, NWS twice-daily upper air soundings, and data from a site-specific meteorological instrument can be processed in AERMET. For this analysis, NWS surface and upper air data were used and were supplemented by NCDC 1-minute surface data. The NCDC data was processed with AERMINUTE.

The nearest and most representative meteorological station is located at the Pittsburgh International Airport in Pittsburgh, PA, which is approximately 25 miles southeast of the facility. NCDC surface data, NWS surface data, and NWS upper air data are all available for this station, and five consecutive years of data (2006-2010) were processed through AERMET. Onsite meteorological data was available at the monitoring station nearest S.H. Bell; however, the data contained numerous hours with exceptionally high wind speeds that called the entire dataset into question. Because the accuracy of data could not be verified, it was not included in the analysis.

VI. Receptors

The 86 receptor locations were provided by ATSDR. The receptors were chosen based on areas of interest to SFSU and ATSDR in the vicinity of S.H. Bell. Three additional receptors were placed at the monitoring locations in East Liverpool: 2200 Michigan (Water Plant), 500 Maryland (school), and 1250 George (Port Authority).

VII. Emissions Inventory and Source Parameters

The pollutant of concern at S.H. Bell is manganese. The evidence is currently inadequate to determine the carcinogenicity of manganese; however, manganese has the potential to cause other non-cancer health effects. The critical effect of an inhalation exposure to manganese is the impairment of neurobehavioral function.

Unfortunately, no comprehensive emissions or modeling inventory exists for the sources at S.H. Bell. Due to the ever-changing operation (including location and types of releases) and materials processed, it is very difficult to develop a representative set of modeling parameters. However, in order to develop an exposure estimate as requested by the SFSU, modeling was performed using generic release parameters and a unit emission rate.

The facility was modeled as an area source covering approximately 46 acres (or 186,155 square meters). A unit emission rate of 1 gram per second was assumed to be emitted equally across this area. The release height was assumed to be 3 meters off the ground, which was chosen because it is a reasonable height for many common processes at a facility like S.H. Bell.

VIII. Modeling Results

AERMOD predicted a 5-year average manganese concentration at each modeled receptor. However, because the release parameters and the emission rates were not necessarily representative of the actual processes at the facility, the predicted concentrations themselves are of little value. Regardless, they still provide a way to estimate comparative exposure between locations. The highest predicted concentration was used as the basis for creating a ratio; all predicted concentrations were divided by the highest predicted concentration. The results can be found in the spreadsheet entitled "Results_RB.xls."

IX. Uncertainties

In any modeling study, there are always uncertainties that must be taken into account when considering the results. This section will highlight some of the specific uncertainties associated with modeling S.H. Bell.

1) This analysis is not an exposure analysis, as it does not take activity patterns or other variables into account; however, modeled long-term average concentrations can be used for a conservative surrogate for inhalation exposure. This assumes that a person is exposed to these modeled concentrations for 24 hours a day for 70 years, which is likely to overestimate the actual exposure.

2) Dispersion models are better at predicting the maximum expected values in a general area, but they are somewhat limited in their ability to determine a specific concentration at a specific location. This uncertainty could over- or under-predict the ambient concentrations.

3) Due to the lack of facility-specific information, the source parameters and emission rates for the facility were based entirely on generic assumptions. First, it was assumed that the annual emission rate as calculated in tons per year would be emitted equally in grams per second per meter squared over the entire year. This is unlikely to be the case, but we have no basis for allocating variable emissions, and this is standard modeling procedure. Specific processes at the facility were not taken into account, and a unit emission rate was used. This could over- or under-predict the facility's ambient impact on the annual average.

5) Building dimensions for use in the Building Profile Input Program (BPIP) preprocessor were not included in this modeling study. BPIP determines whether stacks are being subjected to wake effects from structures, and it calculates building heights and projected building widths to determine if there is any resulting building downwash. Generally, the use of BPIP increases concentrations near the fenceline; thus, this may under-predict concentrations closer to the facility fenceline.

X. References

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